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(19)

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(54) IMPROVEMENTS IN OR RELATING TO THE MOULDING OF HOLLOW ARTICLES

(71) We, MITSUI TOATSU CHEMICALS, INC., a Japanese Body Corporate, of 2—5, Kasumigaseki 3-chome, Chiyoda-ku, Tokyo, 100, Japan, and KUREHA KAGAKU KOGYO KAABUSHIKI KAISHA, a Japanese Body Corporate, of No. 1—8, Horidome-cho, Nihonbashi, Chuou-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method for moulding hollow thermoplastic articles and an apparatus for making such hollow articles, and especially, to a method and apparatus for moulding hollow articles of thermoplastic resins wherein each parison is heated in a manner as to have appropriate temperature difference in the respective axial portions of the parison so that the resultant hollow article is suitably controlled as to thickness in a lengthwise direction.

In general, methods of blow-moulding thermoplastic resins can be broadly classified into three categories, i.e., a cold parison moulding method, a hot parison moulding method and a cold sheet moulding method. Most hollow articles are now produced by a cold or hot parison moulding method using resin tubes or so-called " parisons ". In this sense, this invention concerns a cold parison moulding method or a biaxially stretching and blow-moulding method (hereinafter referred to simply as stretch and blow moulding) which comprises a parison producing step and a heating, stretching and blowing step.

In the case where plastic containers which have a flat or irregular form in section, or the diameter and sectional area of which vary to a great degree in a lengthwise direction, are produced by a hot parison moulding method, the thickness of the ultimately desired mouldings is made uniform by suitably controlling the thicknesses of portions of a molten parison, which is extruded by means of an extruder or which is produced by the use of an injection moulding machine, according to the shape of the ultimate mouldings. That is, upon extrusion of a molten parison, a die or core which has an angle with respect to an extruding direction is moved vertically for changing the clearance between the die and the core thereby to control or change the thicknesses of a molten parison in a lengthwise direction (i.e., a parison-thickness control method). Furthermore, the control of thickness of a molten parison in the circumferential direction can be achieved by the use of a flat or deformed extrusion die or core, so that it is possible to produce a container which has greatly different diameters in the respective body portions thereof without unnecessarily increasing the weight of the container, or to form a container, which is flat or deformed in section, with a uniform thickness in all portions of the container, or to make uniform the bottom thereof which is generally apt to become thin.

In a cold parison moulding system which comprises a parison-producing step and a blowing step, the two steps being independent each other, it is general to produce parisons by continuously extruding cylindrical pipes, followed by cutting, so that it is almost impossible to change or control in a lengthwise direction the thickness of a parison in accordance with the shape of an ultimate container product. Furthermore, the control of thickness in the circumferential direction does not prevail to such an extent as in the hot parison moulding system since it is difficult to place in the correct position in a metal mould a cut parison with a thickness which varies in the circumferential direction and requires a complicated apparatus. Accordingly, when containers having irregular shapes in section are moulded by a cold parison-moulding method without controlling the thickness of the parison, extremely thin wall portions may be formed in such irregularly shaped containers. To avoid this, it is necessary to undesirably increase the entire thilckness of the starting parisons to a greater extent, so that the ultimate containers disadvantageously increase

in weight, resulting in increase in production costs and reduction in transparency of the containers.

Especially with a stretch and blow moulding system wherein the blow moulding temperature is low, a parison becomes poor in mouldability and accordingly, upon expansion by blowing, the thicknesses of portions of the parison, which are not in contact with a metal mould at an initial stage of the expansion, i.e., long span portions of a container with a flat or deformed section and a great diameter body portion and a bottom portion of a container which has different body diameters therein or which is formed by a wide range of expansion ratios, are made extremely thin in comparison with the remainder of a container, e.g., a small diameter body portion, the resultant container having an extremely non-uniform thickness distribution.

In accordance with this invention there is provided a method of forming biaxially oriented hollow articles having an irregular configuration with respect to a particular axis comprising:

(a) introducing a tubular thermoplastic parison having a uniform thickness into a heating zone and imparting sufficient primary heat to bring the parison as a whole to a first orientation temperature within 1° C. temperature tolerance;
(b) imparting additional heat uniformly to the entire circumference to an axial portion of the parison which corresponds to a portion of a hollow article having a relatively smaller expansion ratio than the remaining portion, i.e. a small diameter body portion of the hollow article to bring the entire area of the said axial portion to a second temperature which is higher by 1—5° C. than that of the remaining portion of the parison;
(c) axially stretching the heated parison;
(d) placing the stretched and heated parison into a moulding cavity having an irregular circumferential configuration with respect to the longitudinal axis of the parison when disposed therein, the said axial portion of the parison being disposed in axial alignment with a portion of the moulding zone having a circumferential dimension which is less than the maximum circumferential dimension of the moulding cavity, and
(e) creating a pressure differential to expand the parison out into conformity with the moulding cavity.

Preferably the parison is cylindrical and preferably the method includes the step of rotating the parison in proximity to a first auxiliary source of heat during step (b). The temperature difference between the said axial portion and the remainder of the parison must be controlled within 1 to 5° C., being dependent upon the difference of the expansion ratios of the resultant hollow article. Conveniently the thermoplastic material is polypropylene, the first temperautre is approximately 155° C. and the second temperature is approximately 159° C.

There is also provided in accordance with this invention an apparatus for heating, axially stretching and blow moulding parisons in a moulding cavity for forming biaxially oriented hollow articles having an irregular configuration with respect to a particular axis comprising:

an oven;
conveyor means for transporting tubular parisons along a circuitous path in the oven; the conveyor means including a series of support means for holding each of the parisons in positions for rotation about their respective central axis while being transported along the circuitous path;
the oven having primary heating means for bringing the parison as a whole to a first orientation temperature within 1° C. temperature tolerance, and also auxiliary heating means disposed along a predetermined length of the circuitous path for uniformly heating an axial portion of a parison to a temperature which is higher by 1—5° C. than that of the remainder of the parison;
means for rotating a support means for a parison while exposed to the auxiliary heating means;
means for stretching the heated parison axially in opposite directions after taking it out of the oven, and means for blow moulding of the heated and stretched parison when placing it into a moulding cavity the shape of which is dependent upon the difference of the expansion ratio of the resultant hollow article.

A known stretcher and a fluid-blowing means may be provided for axially stretching the heated parison, followed by blowing thereinto a pressurized fluid or air mould.

Preferably the auxiliary heating means includes means for heating at least two axially subdivided portions of the parison to temperatures different from each other and from that of the remainder of the parison.

The thermoplastic materials useful in the present invention may be chosen from thermoplastic resins capable of blow-moulding by the cold parison-moulding method, especially high density polyethylene, low density polyethylene, polypropylene, polyvinyl chloride and polyvinylidene chloride. These thermoplastic resins may be used in combination with a thermoplastic resin of a different type in the laminated form.

This invention is very effective when applied to the production of containers the body diameter of which varies in a lengthwise direction, e.g., a container having a conical form or a container with a narrow body part. However, this invention is not limited to the production of containers with such specific forms or shapes and is also effective for the production of general cylindrical containers with the bottom being made strong and uniform in thickness. The heating source of the auxiliary heating means is not limited to a specific type but may be an infrared heater, a silica tube heater, a far-infrared heater, a hot air generator, a steam heating device and the like.

The primary source of the heating apparatus which includes therein the auxiliary heating means is not limited to those of a specific type and may be the same type of heating source as used in the auxiliary heating means. In either case, the heating source is required to precisely control the temperatures within 1° C.

Where the temperature difference in the axial direction of the parison attained by using the auxiliary heating means is smaller than 1° C., it is difficult to make uniform the thickness of a final product and the maintenance of such small temperature difference will be almost impossible. However with a temperature difference in excess of 5° C., good moulding products cannot generally be obtained since the portions heated by the auxiliary heating means are expanded to an excessive extent and so-called "necking" will tend to take place.

The heating apparatus is generally required to be so designed as to vertically support parisons upon respective supporting pins and to be capable of circulatingly feeding or conveying the parisons through the heating device. Furthermore, when the parisons pass by the auxiliary heating means, it is usually necessary to permit the parisons to rotate together with the respective supporting pins so that the parisons are uniformly heated in a circumferential direction.

By way of example a preferred form of heating apparatus embodying the invention will be described in detail with reference to the accompanying drawings, in which:

Figure 1 is a plan view of a heating apparatus illustrative of the invention;

Figures 2 and 3 are vertical sectional views taken along lines A—A and B—B respectively in Figure 1;

Figure 4 is a plan view taken along line C—C in Figure 3;

Figure 5 is a front view of a hollow article obtained by use of the heating apparatus, and

Figure 6 is a bottom view of the container of Figure 5.

Figure 1 is a plan view of the heating apparatus including auxiliary heating means indicated by 1, a hot air port of the heating apparatus indicated by 2, a parison-conveying or feeding chain indicated by 3, axes for returning the conveying chain 3 indicated by 4 and 4′, a heating oven indicated by 5 and means for introducing a parison into the heating oven 5 indicated by 6.

With reference to Figures 2 and 3 a parison-supporting pin is indicated by 7, a gear wheel for rotating the supporting pin 7 is indicated by 8, a parison indicated by 9, a fixed sprocket mating with the gear 8 indicated by 10, a shaft supporting the pin 7 indicated by 11 and a chain guide indicated by 12.

Referring now to Figures 1, 2, 3 and 4, the chain 3 which carries the parison-supporting pins 7 is endless and circulatively runs in the direction of the arrows shown in Figure 1. The heating oven 5 is entirely uniformly heated up to a predetermined moulding temperature T by hot air (primary heating) which is blown thereinto through the hot air ports 2. The parison 9 which is put on the supporting pin 7 with the aid of the parison-introducing means 6 is fed through the heating apparatus for uniformly heating the entirety thereof and comes to the position where it encounters the auxiliary heating means 1 on its next to last pass of the conveyor means. The auxiliary heating means 1 constitutes, for example, sets of three far-infrared heaters which are set in position to heat the upper, middle and lower portions of the parisons, respectively, and which are adjustably mounted to be movable up and down in a vertical line. Moreover, the auxiliary heaters are respectively connected to voltage regulators to suitably control the quantity of heat. The parison 9 which is mounted on the supporting pin 7 is fed through the oven in the direction of the arrows while allowing it to rotate at a constant rotational frequency by means of the gear 8 mating with the fixed sprocket, during which certain portions of the rotating parison are further heated for a predetermined period of time by the auxiliary heating means. As a result, the upper, middle and lower portions or parts of the parison are uniformly heated in a circumferential direction up to a temperature of $(T+t_1)$°C., $(T+t_2)$°C. and $(T+t_3)$°C., respectively. The thus heated parison is then fed to a subsequent stretching and blowing step to shape the same into a desired form.

EXAMPLE.

Reference will be made to the accompanying drawings.

Polypropylene having a density of 0.900 g/cc (at 20° C.) and a melt index of 0.5 g/10 min. (ASTM—D°1238—62T) was used as a raw material for producing, by

means of an extruder and a parison cutter, parisons each having an outer diameter of 22 mm, a thickness of 5 mm, an inner diameter of 12 mm and a length of 120 mm. The resultant parison was heated to 155° C. (hereinafter referred to as T° C.) by the use of the heating apparatus of Figure 1. The upper portion (i.e., portion A (expansion ratio 1.6) in Figure 5) of the parison was further heated by the auxiliary heating means up to T+4° C., the middle portion (i.e., portion B (expansion ratio 2.3) in Figure 5) up to T+2° C., but the lower portion (i.e., portion C (expansion ratio 3.0) in Figure 5) was not supplementarily heated. The thus heated parison was withdrawn from the oven and the ends of the parison were grasped by conventional apparatus for stretching the parison by about 2.5 times as long at a constant rate in the direction of a tube axis. The thus stretched parison was immediately placed in a metal mould having an internal configuration as shown in Figures 5 (front view) and 6 (bottom view), and a pressurized fluid, such as air, was blown into the parison to mould a container. The thickness distribution of the container which was obtained by the use of the auxiliary heating means in accordance with the present invention is shown in the Table below in comparison with that of a container obtained as a result of conventional uniform heating. The measured points are indicated by numerals corresponding to those of Figure 5.

Measured point	Thickness (mm)			
	Container of invention		Container of prior art	
	Front	Side	Front	Side
1	1.0		1.2	
2	1.0		1.1	
3	1.0		0.9	
4	0.9		0.8	
5	0.8		0.6	
1'		0.5		0.8
2'		0.6		0.6
3'		0.5		0.4
4'		0.5		0.3
5'		0.4		0.1

It will be apparent from the Table that the thickness distribution of the container obtained by the use of this invention is markedly uniform when compared with the container which is obtained from the same kind of parison uniformly heated by a conventional manner.

As for the moulding of containers of different shapes, substantially the same results can be obtained by suitable control of heating intensity, heating position and heating time. It should be noted that the above-described specific apparatus is intended to merely illustrate one preferred embodiment of the present invention.

WHAT WE CLAIM IS:—

1. A method of forming biaxially oriented hollow articles having an irregular configuration with respect to a particular axis comprising:

(a) introducing a tubular thermoplastic parison having a uniform thickness into a heating zone and imparting sufficient primary heat to bring the parison as a whole to a first orientation temperature within 1° C. temperature tolerance;

(b) imparting additional heat uniformly to the entire circumference of an axial portion of the parison which corresponds to a portion of a hollow article having a relatively smaller expansion ratio than the remaining portion; to bring the entire area of the said axial portion to a second temperature which is higher by 1—5° C. than that of the remaining portion of the parison;

(c) axially stretching the heated parison;

(d) placing the stretched and heated parison into a moulding cavity having an irregular circumferential configuration with respect to the longitudinal axis of the parison when disposed therein, the said axial portion of the parison being disposed in axial alignment with a portion of the moulding cavity having a circumferential dimension which is less than the maximum circumferential dimension of the moulding cavity, and

(e) creating a pressure differential to expand the parison out into conformity with the moulding cavity.

2. A method according to Claim 1, in which the parison is cylindrical, and which includes the step of rotating the parison in proximity to a first auxiliary source of heat during step (b).

3. A method according to Claim 1 or Claim 2, wherein the thermoplastic material is polypropylene the first temperature is substantially 155° C. and the second temperature is substantially 159° C.

4. A method according to Claim 1 substantially as herein described with particular reference to the drawings and/or the example.

5. A hollow article which has been made by the method of any preceding claim.

6. An apparatus for heating, axially stretching and blow moulding parisons in a moulding cavity for forming biaxially oriented hollow articles having an irregular configuration with respect to a particular axis comprising:

an oven;

a conveyor means for transporting tubular parisons along a circuitous path in the oven, the conveyor means including a series of support means for holding each of the parisons in positions for rotating about their respective central axis while being transported along the circuitous path;

the oven having primary heating means for bringing the parison as a whole to a first orientation temperature within 1° C. temperature tolerance, and also auxiliary heating means disposed along a predetermined length of the circuitous path for uniformly heating an axial portion of a parison to a temperature which is higher by 1—5° C. than that of the remainder of the parison;

means for rotating a support means for a parison while exposed to the auxiliary heating means;

means for stretching the heated parison axially in opposite directions after taking it out of the oven, and means for blow moulding of the heated and stretched parison when placing it into a moulding cavity the shape of which is dependent upon the difference of the expansion ratio of the resultant hollow article.

7. An apparatus according to Claim 6, wherein the auxiliary heating means includes means for heating at least two axial portions of the parison to temperatures different from each other and from that of the remainder of the parison.

8. An apparatus according to Claim 6 or Claim 7, wherein the auxiliary heating means comprises an elongated fixed source of heat disposed parallel to the predetermined length of the circuitous path.

9. An apparatus according to any one of Claims 6 to 8, wherein the conveyor means includes endless chain means, the chain means comprising a pair of parallel endless chains adapted to move in opposite directions, the auxiliary heating means being disposed between the two parallel endless chains.

10. An apparatus according to Claim 9, wherein the support means includes a shaft including a gear and rotatably journaled on the chain means, and fixed sprocket means engaging with the gear along the predetermined path.

11. An apparatus according to any one of Claims 6 to 10, wherein the support means includes shaft means journaled on the chain means for rotating a parison about a vertical axis, the auxiliary heating means including at least two elongated heating means disposed in vertical superimposition.

12. An apparatus according to any one of Claims 6 to 11, wherein the auxiliary heating means comprises a source of infrared heat.

13. An apparatus for heating parisons substantially as herein described with particular reference to the accompanying drawings.

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Fig.1.

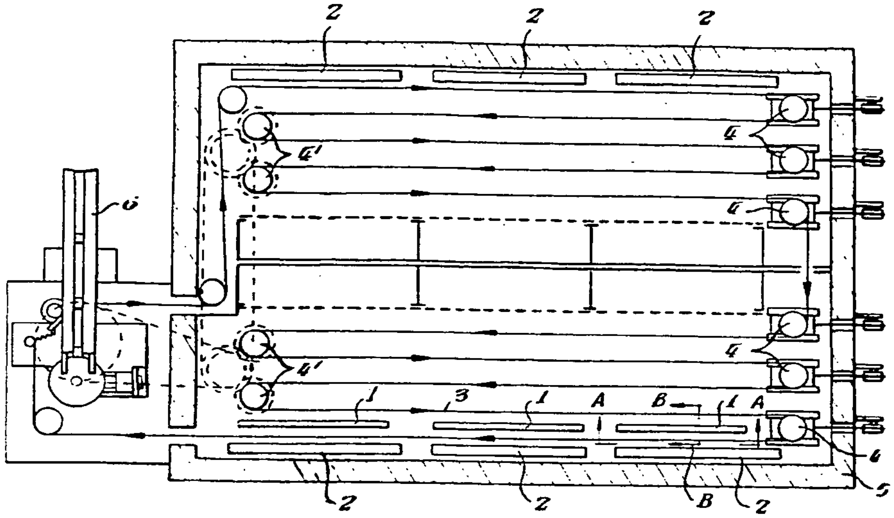


Fig.2.

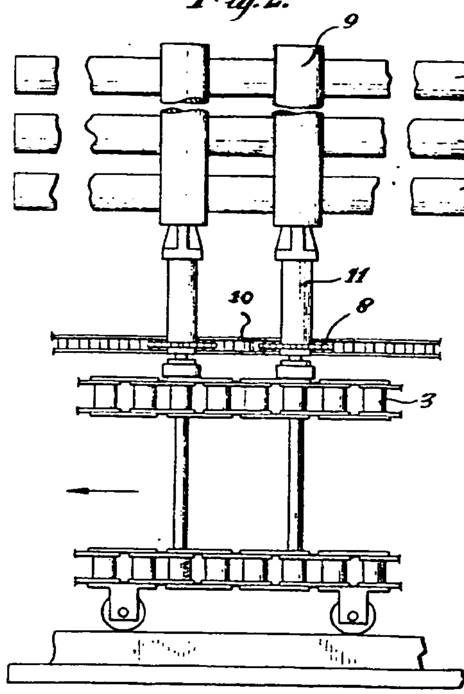
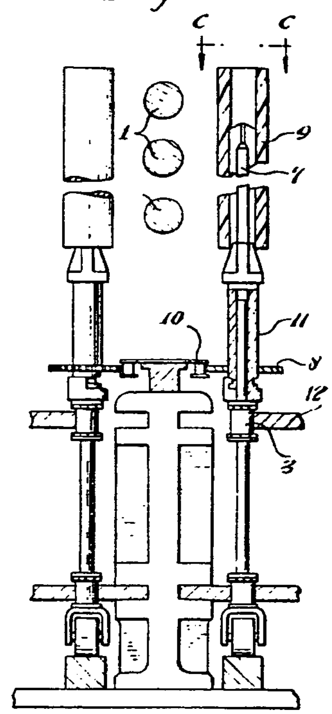


Fig.3.



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Sheet 2

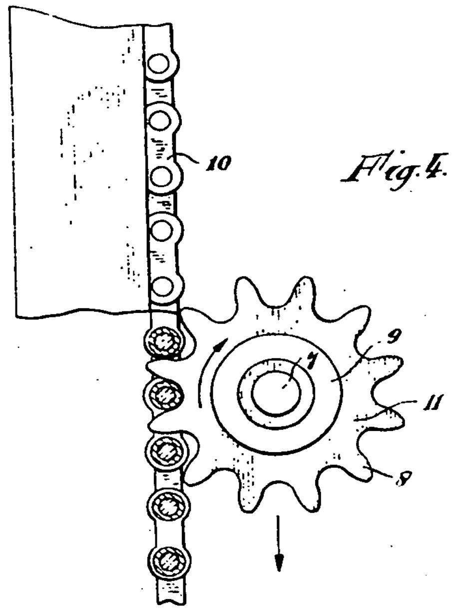

Fig. 4.

Fig. 5.

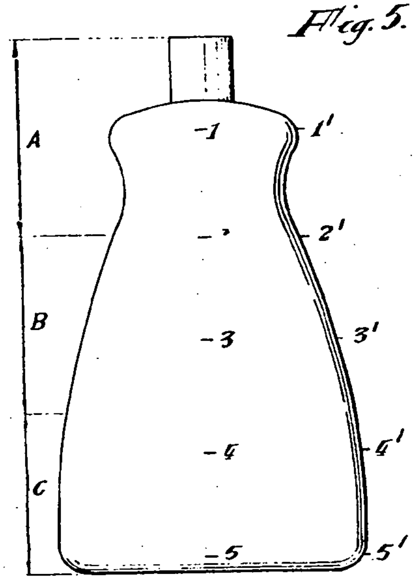

Fig. 6.

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